BGCAPP

Blue Grass Chemical Agent-Destruction Pilot Plant

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A Partnership for Safe Chemical Weapons Destruction

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Supercritical Water Oxidation

The Blue Grass Chemical Agent-Destruction Pilot Plant (BGCAPP) will safely destroy a chemical weapons stockpile that comprises more than 500 tons of blister and nerve agents in weapons stored at the Blue Grass Army Depot. The plant will eliminate the nerve agent weapons using a two-step process.

Step one consists of a process that will neutralize the nerve agent. The munitions will be disassembled to separate the agent from the energetics, which will then be mixed separately with either a caustic solution or water to destroy the chemical agent and energetics before being temporarily stored for later treatment. The resulting products are known as hydrolysate.

Step two involves a secondary process called supercritical water oxidation (SCWO), which will be used for final treatment of the hydrolysate at BGCAPP. This fact sheet explains how SCWO works and provides background information on how it has been tested in preparation for use at BGCAPP.

This computer graphic illustrates the SCWO reactor vessel, which will combine water, fuel, air and hydrolysate. The hydrolysate is oxidized to carbon dioxide, water and salts.

The Science of SCWO

The SCWO process will blend water, fuel, air and hydrolysate together in a specialized vessel at temperatures and pressure conditions above the critical point of water.

A supercritical fluid is defined as a substance that is above a specific temperature and pressure, known as its critical point.

The critical point is unique for every substance. For water, the critical temperature and pressure are 705 degrees Fahrenheit and 3204 psi, respectively. Above the critical point, the liquid and gaseous phases become indistinguishable – existing neither as a liquid nor a gas, but as a homogeneous dense fluid. Water above its critical point is referred to as supercritical water, and may be thought of as very dense steam.

Supercritical water has unique properties and is much different from water at room temperature. Salts and other polar compounds that are normally soluble will drop out of solution at supercritical conditions. On the other hand, nonpolar organic compounds — materials that normally form a separate phase when mixed with liquid water — become highly soluble in supercritical water and are quickly converted to form carbon dioxide and more water in the presence of oxygen (also fully soluble).

For instance, imagine taking a glass of salt water with an oil layer on top and increasing the temperature and pressure above the critical point of water to supercritical conditions. The salt would separate from the water, and the oil would fully dissolve, leaving you with a glass containing a dense oil-water mixture at the top and salt at the bottom. If oxygen were added, the oil would rapidly and cleanly oxidize to form carbon dioxide and water. In a similar manner, the organics in the hydrolysate channel and oxygen mix together in the SCWO vessel and react to break down the hydrolysate, creating carbon dioxide, water and salt products.

After concentration, this brine solution will be shipped off site to a licensed treatment, storage and disposal facility. For conservation purposes, about 70 percent of water used in the SCWO process will be recycled back into the BGCAPP facility.

Testing Ensures Performance

SCWO is a tested and proven technology. There are currently six full-scale SCWO plants operating worldwide, including one at the Defense Ammunition Center at the McAlester Army Ammunition Plant in Oklahoma. Others are located in France, Japan, Korea and the United Kingdom. However, BGCAPP will be the first industrial-scale facility to combine the two technologies of neutralization and SCWO. As a result, the Program Executive Office, Assembled Chemical Weapons Alternatives (PEO ACWA), which is responsible for the destruction of the Kentucky chemical weapons stockpile, has conducted more than 7,000 hours of testing on the SCWO process. An additional 12-month full-scale testing period was completed at the SCWO fabrication facility prior to sending the units to the BGCAPP site. As with all BGCAPP systems, once the SCWO units are completely installed at the BGCAPP site, further testing will be completed until operational conditions are satisfactorily established, and the BGCAPP team is confident that SCWO will be a safe and efficient secondary treatment process.

The National Academies of Sciences, Engineering and Medicine (formerly the National Research Council) evaluated the SCWO Intermediate Design and Technical Risk Reduction Program in July 2006. The National Academies recommended additional testing using a full-scale reactor at full-scale conditions. Teams from ACWA and Bechtel Parsons Blue Grass addressed the recommendations by completing the full-scale testing period referenced above.

In addition, the Army Research Office convened an independent panel of SCWO process experts and evaluated ACWA and Bechtel Parsons Blue Grass' intended path forward in September 2006. The panel evaluated the Technical Risk Reduction Program to determine if adequate measures were in place to address the risks identified by the National Academies. The panel concluded that the testing to be conducted was adequate.

The use of neutralization followed by SCWO has been independently reviewed and endorsed by the governor-appointed Kentucky Chemical Demilitarization Citizens' Advisory Commission.